The Effect of Multiple Input Devices on Collaboration and Gender Issues

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The KidStory project aims to develop technologies that encourage young children to work collaboratively in the classroom. KidPad, a drawing and zooming tool, has been developed to be used with one, two or more mice to support children's 'shoulder-to-shoulder' collaboration at the computer. The study described in this paper explores how multiple input devices impact on pairs' interactions at the computer and the work they produce together. Preliminary analyses suggest that two mice can aid collaborative behaviour. However there are marked differences in the quality of collaboration dependent on the gender of the children involved.
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Introduction

Learning environments supported by technology offer an ideal opportunity for collaboration by providing a shared goal where working with others will genuinely lead to an improved solution (Barfurth, 1995). However, learning will not take place just because two students share the same computer. The technology needs to provide support for peer interactions in a way that will lead to learning gains (Suthers, 1999). Research has shown that a number of factors affect collaboration at the computer, these include task, group size, gender and ability mix (O'Malley, 1992). Different combinations of users (number, ability and gender), computer systems and software designs will induce differences in collaborative interaction.

Traditional computer software and hardware have been designed with only one user in mind; two users must share a mouse or keyboard and control over one cursor on the screen. This may result in an unequal balance between two children collaborating with boys more likely than girls to take control of the mouse when access was limited (Light and Glachan, 1985). When sharing one mouse in a group activity there can be an unequal balance between the participants who contribute ideas – this may favour those who are not controlling the mouse (Cole, 1995).

There have been limited investigations into how the modification of some of the standard input features of a computer may affect collaboration. A few studies have shown that dual keyboard input or mice have been found to improve performance and collaboration (Light, Foot and Colbourn, 1987; Inkpen, Ho-Ching, Kuederle, Scott and Shoemaker, 1999)

However, collaborative effects may differ due to the nature of the task that is chosen and even due to the appearance or interface to the task. For example, Cohen (1994) highlighted the difference between 'structured' and 'ill- structured' tasks. Structured tasks are those that are more formal and have an eventual correct answer. The way that interaction factors predict outcome factors differs for the two types of task. The amount and quality of interaction is a more crucial factor for ill- structured tasks. The majority of studies looking at interaction with a computer-based task have used structured planning or problem solving tasks. Fewer studies have looked at more creative or open- ended tasks.

Many studies have found gender differences in the way that pairs interact whilst completing a task and these are often found even if there is no difference in the outcome measures. Hoyles and Sutherland (1989) found differences in the nature of the collaboration and attitudes between boys and girls on a programming task. Yelland (1995) also used a series of programming tasks and found that although there were no differences in performance measures there were differences in interaction. Girls showed more verbal interaction especially in offering information and asking for, offering and agreeing with proposals.

Gender effects seem to interact with the type of task. Hughes and Greenhough (1989) found that female pairs performed worse than either male pairs or mixed pairs on a programming task. Underwood, Jindal and Underwood (1994), however, found that mixed pairs performed worse than either male or female pairs on a cloze task, which required children to fill in blank letters in a short passage.

The nature of the interaction in mixed pairs is not as successful as single gender pairs and there are often failures in communication. Mixed pairs may share the task in different ways (Underwood et al., 1994), show lower levels of interaction with fewer suggestions (Underwood, Underwood and Wood, 2000) but more uncoordinated and assertive responses (Fitzpatrick and Hardman, 1994) and in mixed groups boys often dominate the interaction (Siann and MacLeod, 1986). The problems encountered by certain gender pairings may be compounded by access to hardware when only a single mouse and keyboard are used.

The KidStory project aims to explore the development of new technologies that encourage collaboration (Benford et al., 2000). Encouraging collaboration is more proactive than merely enabling collaboration. Something new is gained by choosing to work together, although the children may work independently if they wish. On the other hand, it is not as rigid as enforcing collaboration, for example by demanding that two children have to synchronize their actions in order to succeed.

In KidStory the features of the technologies, the tasks they support, and the input devices used to interact with the technologies have been developed or adapted to better support collaboration. For example, the software developed supports the use of two or more mice, enabling two children to interact with the computer simultaneously. This study investigates how the use of two mice affects collaborative behaviour around the shared desktop.

Most previous studies have used a structured problem- solving task but in this study a more creative task was used. The present study investigated both gender composition, and whether or not the pairs had one or two mice, in using KidPad to create a story. The effects of gender pairing and mouse condition on the quality of the product were examined. In addition the verbal interactions between the pairs were studied to investigate whether there were any differences in the nature of the interaction and whether any particular style of interaction leads to improved performance.

In line with previous studies mentioned above it was expected that there would be a difference in performance with single gender pairs outperforming mixed pairs. In the two mice condition the performance of all the groups should improve and the mixed pairs should improve to the level of the single gender pairs. It was predicted that analysis of the interaction would show that there is a difference in the interaction styles between the different gender pairings and that successful performance would be correlated with certain utterance types – giving suggestions, asking opinions and discussing ideas.

Method

Participants

Thirty-six participants from Albany Infants School in Nottingham took part in the study. Half of the participants were male and half were female. The age range was 5 years 10 months to 7 years 5 months and the mean was 6 years 9 months. Since the school has mixed age classes 9 of the children were Year one pupils and 27 were Year two pupils. The Year one pupils were divided equally between the conditions.

The children were all familiar with the researchers, who had been working in the school for the previous eighteen months. They were also familiar with the software, having been tutored in using all of the features of KidPad.

In keeping with many practice in many studies of collaborative learning, children were split into friendship pairs by the teacher. These were balanced so that there was an equal number of female pairs, male pairs and mixed pairs. Each pair was ability rated by their class teacher into five categories so that pair ability and gender could be balanced between the one mouse and two mice conditions.

Design

The study was a between groups design with 2 independent variables. The first independent variable was the mouse condition which had two levels – one mouse and two mice. The second independent variable was the gender pairing of the participants consisting of three levels – male pairs, female pairs and mixed pairs.

The dependent variables collected were process and performance measures. The sessions were transcribed and coded according to type of utterance to provide the process measure. The quality of stories produced was evaluated by six independent raters to provide the performance measure. The raters were shown video clips of the participants presenting their story to an experimenter. They could also see what the children had drawn on the computer. They were told to decide which of the elements of the story the children had included. They were also asked to rate each element on a five point Likert scale.

Apparatus and Materials

Technical Apparatus

KidPad version 7.0 was displayed on a Pentium II PC with a 17" monitor, keyboard and one or two mice (dependent on condition). In the two mice condition each child had a mouse mat on the table in front of them. In the one mouse condition there was one mouse mat placed centrally in front of the pair. A small digital video camcorder was placed on top of the monitor to allow the children's faces and hands and the mouse / mice and keyboard to be captured as well as audio. When the children presented their story at the end of the session the video camera was hand held to allow the children and the monitor to be recorded. A scan converter was used to record the image appearing on the computer screen and a quad video mixer was set-up to simultaneously show this image next to the video recorded image of the children's hands and faces (see Figure 1).

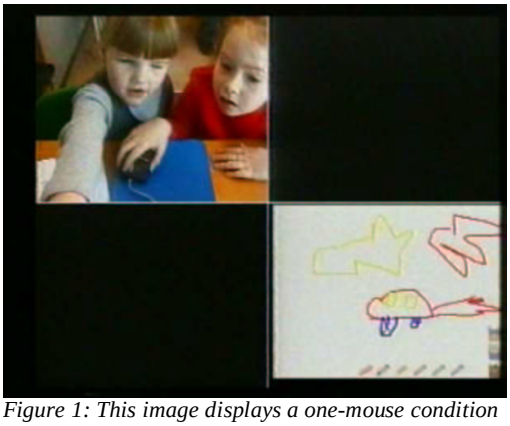

Figure 1: This image displays a one-mouse condition with 2 girls creating the story shown in the right hand corner

Software

KidPad is a shared 2D-drawing tool that incorporates a zooming interface. Children can bring their stories to life by zooming between drawing elements. The zooming and spatial structure enable children to add narrative structure to their stories by dynamically moving between different parts of a drawing, allowing the development of non-linear, complex structured stories. The KidPad interface is designed around a series of graphical "local tools" that children pick up and apply using a mouse. KidPad encourages collaboration by allowing "tool mixing" - when two (or sometimes more) children each use mixable tools at about the same time and place, the tools give enhanced functionality. An example of this approach is the use of crayons. If two children draw with two crayons close together, then the result is a filled area between the two crayons where the colour is the mix of the two. In this case, the children are not prevented from drawing as individuals, but they can gain additional benefit (new colours and filled areas) by working together. This software is described in more detail in the paper by Benford et al., 2000.

Task

KidPad is predominantly used for storytelling and this activity is generally open and unstructured, meaning that each experience with KidPad is individual. In order to examine collaboration during the execution of such a creative activity the task chosen would need to be structured sufficiently to allow some degree of comparability between participants whilst retaining its appropriateness for the setting and participant group. In addition the task should keep the children occupied for at least 20 minutes, provide motivation, a shared focus and allow the children to use features of KidPad in order to fulfil the task requirements.

The story creation task chosen originated from a short four line poem "Twinkle Twinkle Chocolate Bar" (see appendix 1) which the children were asked to recreate using KidPad. The poem was chosen with the advice of one of the class teachers and was familiar and popular with the whole class. It was also chosen because it was short but contained enough elements within it to keep the children working for 20 minutes and gave plenty of opportunity to use all the KidPad tools

Procedure

The experimental sessions took place in the corner of the classroom on a computer situated in its usual position. The sessions took place during a lesson (usually Maths or English). The background conditions – time of day, lesson within which the study took place, were kept as constant as possible. At the beginning of each session the children were introduced to the task and were told that they were going to use KidPad to tell a story. The poem was read to them and they were asked to recreate it using KidPad. They were told that when they had finished they would show their story to the class teacher. It was emphasised how important it was that they worked together.

Figure 2: The children worked on the task in the corner of the classroom

After 20 minutes the children were asked to save and present their story. The presentation was to an unfamiliar person who had not been the experimenter for the session. The purpose of the presentation was to provide a performance measure for the quality of the story and to act as motivation and maintain the interest of the children. They were video recorded whilst presenting the story and told that the video would be shown to their class teacher. Whilst they were presenting they were asked to point out and describe all the things that they had drawn.

The majority of pairs focused well on the task, however if pairs did not keep to task the experimenter reminded them that they had to present the finished work. The experimenter was also on hand during the session to assist where necessary with any technical problems the participants may have had using the software.

Results and Discussion

Analysis of dialogues

The children's utterances were transcribed and coded in order to analyse the interactions. A coding scheme was developed to capture the important distinctions in styles of discussion between the pairs. The categories distinguish between directions, suggestions and own ideas and also record requests for opinion or suggestion. Different styles of paired work are characterised by different frequencies of these categories. When work is truly collaborative both partners make contributions to the decisions that are made, partners take note of and seek out each other's opinions and suggestions and there is a balance between the level of the work that each member of the partnership undertakes. In contrast one 'worker' may dominate the other with more instructions and directions and fewer requests for opinion. If partners are working independently there will be less discussion about group work and children may only talk about what they are going to do next. There will typically be a lower level of discussion overall. The coding scheme was piloted and discussed and was refined to produce the final, hierarchical version used (see appendix 2).

Ten-minute sections from the middle of the recorded sessions were transcribed. Each utterance was coded as one of 12 mutually exclusive categories. A second rater coded two of the transcripts in order to assess inter-rater reliability. There was a correlation between the raters of 0.97. Cohen's Kappa (Cohen, 1960), which takes account of chance, was also calculated and gave a value of 0.67.

Analysis of the category frequency by mouse conditions showed that there was a difference in the number of statements giving intentions or actions about own work. A Mann-Whitney U Test showed that pairs in the two mice condition used significantly more of these statements (mean = 22.78) than those in the one mouse condition (mean = 13.22; $U = 16.50$, $p<0.05$). There was no comparable difference in terms of pairs in the one mouse condition talking more about their joint work. So using two mice did not stop children discussing their joint work but they talked more about what they themselves were doing.

The coded transcripts suggested that the female pairs had the highest overall level of interaction and the mixed pairs the lowest. Kruskal-Wallis tests found that there was a significant difference in the total number of utterances used ($H = 6.89$, $p<0.05$). Post hoc paired comparisons found that the female pairs had a higher level of total utterances (mean = 163) than the mixed pairs (mean = 95). This is an important issue as without sufficient interaction it is not possible to collaborate well, instead the style of work will be more independent. The low level of total interaction was a major problem with many of the mixed pairs. There were far longer periods of no discussion at all than with the female or male pairs. These pairs need to be encouraged to interact because without it they cannot be said to successfully collaborate whatever the final outcome.

There are three categories that are important for collaboration where a difference was found between the gender conditions. These concern opinions or suggestions about joint or own work and requests for suggestions or opinions. Female pairs used more opinions / suggestions about joint work (mean =10.50) than mixed pairs (mean = 3.83; $H = 6.69$, $p<0.05$). Females pairs used more opinions / suggestions about own work (mean = 13.83) than male pairs (mean = 6.17; $H = 6.39$, $p<0.05$). Female pairs also used more requests for suggestions or opinions (mean = 4.83) than both mixed pairs (mean = 2.33) and male pairs (mean = 2.33; $H=7.272$, $p<0.05$).

These results clearly show that the female pairs were using a different style of work from the other pairs. They discussed their ideas more as can be seen in the higher number of suggestions given and requests for opinion. The mixed pairs seemed to work more independently than collaboratively. They did not discuss their ideas but worked either in parallel, each working on their own items when they had two mice, or by turn taking when they were sharing a mouse. The style of working of the male pairs was more diverse. Some of the male pairs used a collaborative style of working that was similar to the female pairs. Other male pairs showed more conflict and disagreement.

Examples taken from the transcripts about how different pairs negotiate the same situation highlight these differences in working style. When there is only one input device the children have to negotiate sharing of the mouse. There appeared to be a difference in the way that this was dealt with for the different gender pairings (see table 1).

The female pairs seemed to share the task more evenly and would give up the mouse to their partner to complete their part. The mixed pairs seemed to be dominated by the boy in the pair. The boy would try to do most of the work and the girl did not try to take the mouse off them but allowed them to take control. In the third example above the girl has the mouse but soon gives it back to the boy. The male pairs showed a lot of tension about the sharing of the mouse, in more than one case this led to them fighting over the mouse. Once they had the mouse they would keep it as long as possible and tended to do what they wanted without taking notice of their partner. In the case of one pair, the boy without the mouse sat back away from the computer seemingly taking very little notice of what was going on until it was his turn to have the mouse again.

Girl – Girl pairs	Boy – Girl pairs	Boy – Boy pairs
Z – " I draw a little bit of the car and then you draw a little bit of the car	D – " My turn now!"	W – "My turn to do it now" tries to take mouse and they fight over it
C – "Can I just do something" P – "course you can"	D – " Wait I'm gonna do something now"	A – "I am going to do that now"
D – "I'll do one wiggle and you do the other wiggle"	S – "Right you can do something if you want to"	S – "I'll do the car because you just did it"

Table 1: negotiating sharing of the input device

For the pairs who had two mice there was often conflict about how they negotiated who would use the tools (see table 2). With the KidPad software it is possible to 'steal' the others tool by clicking on the other cursor. Alternatively it is also possible to both use the same tool by using the 'duplicator' tool.

Again the female pairs took notice of their partner's needs and shared the tools out amicably, making use of the 'duplicator' tool. The boy pairs who made use of the 'duplicator' tool did not have problems with sharing the tools, but those who did not use it often had conflicts with the tools, frequently trying to steal each other's. With the mixed pairs the boys seemed to control use of the tools and what use what they needed without concern for the girls' needs.

Girl – Girl pairs	Boy – Girl pairs	Boy – Boy pairs
R – "Can I take black then" R - " I'll take brown"	T - "I need the blue" T – "Well you can have it in a minute"	J - "Get – click on that, see we've both got black now"
E – "You get the paintbrush and I'll click on you and get another one for me"	A – "Let me get the wobble tool" J – "Oh A – I need that one"	A - "I'm gonna steal yours"
J – "Get that thingy, that one and you can copy mine"	E – "I need that wiggly tool back here, hey don't try and get me!"	M - "Give me back my, now give me back my hand back"

Table 2: negotiating sharing of the tools

Another area where there appeared to be differences between the gender pairings was whether they made joint suggestions or just did their own ideas (see table 3).

The female pairs tended to talk about what they would do and asked each other for ideas and opinions. The male pairs also discussed ideas some of the time but also tended to talk more about their own ideas – "I do this, you do that" etc. The mixed pairs seemed to work independently, often not knowing what each other were doing.

Girl – Girl pairs	Boy – Girl pairs	Boy – Boy pairs
R – "What are we going to do now"	J – "I've drawn a car" A- "Stop it I'm doing the window"	J – "Shall we do twinkle, twinkle chocolate bar"
C – "We could do the car and put a starter and a choke"	O – "What's that for J" J – "I'm gonna put some stars"	S – "Now what shall I do" W – "you have to do the link"
L – "Do you want to draw a dad in it"	T – "Oh T, no T why do you keep doing that"	MG – "Are you doing a little person"

Table 3: Suggestion making

Analysis of children's stories

Six raters evaluated the quality of the stories produced. A mean score for each pair was calculated for the number of items included and the quality score. The mean scores broken down by mouse condition and gender are given in the table 4 below.

	Items			**Quality**		
	one	**two**	**Total**	**One**	**two**	**Total**
girl-girl	4.94	4.11	4.53	16.11	14.89	15.50
boy-boy	3.00	4.88	4.13	7.99	15.17	12.30
boy-girl	3.27	3.72	3.50	9.06	11.67	10.36
Total	3.83	4.24		11.44	13.91	

Table 4: Mean results by gender and mouse condition.

Several trends are suggested from these means. The average for all the participants was higher under the two mice condition. The male pairs performed a lot better in the two mice condition than the one mouse condition whilst the mixed pairs performed only slightly better with two rather than one mouse. Surprisingly the female pairs performed worse with two mice than with one. This may be because the girls work independently when they have two mice, not discussing ideas as frequently and thus collaboration is reduced. Despite some improvement with two mice, the mixed pairs still performed below the level of the single gender pairs. It is not possible to conclude from the improved performance whether the level of collaboration is necessarily better. When examples of dialogue are examined it can be seen that the girls in mixed pairs are still dominated by the boys when it came to making suggestions, discussing ideas and sharing tools. The advantage of using two mice, however, is that the girls in mixed pairs are able to have access to the computer which they may not have when there is only one.

Relationship between process of interaction and outcome

Correlations were performed to determine whether there were any relationships between categories of utterance and outcome measures. For this the participants were treated as individuals rather than pairs. The number of each type of utterance that they used themselves was scored and they were given the performance scores that they had been awarded as a pair. The ages and ability ratings that had been given by the teacher were also entered into the analysis. A Spearmans rho correlation coefficient was calculated.

The first correlation showed a significant relationship between ability rating and both the number of items ($r = 0.61$, $p < 0.01$) and the quality of items ($r = 0.65$, $p < 0.01$). A second correlation was carried out, controlling for ability. There was a significant relationship between the quality of items and suggestions/opinions about own work (category 1b; $r = 0.49$, $p < 0.01$), giving information / explanation (category 4; $r = 0.44$, $p < 0.01$) and the total number of utterances ($r = 0.36$, $p < 0.05$). This suggests that an increase in certain types of discussion can lead to an improvement in the stories produced.

Summary and Conclusions

In summary, we have found that the collaborative version of KidPad with two mice has several advantages. The quality of stories produced by the children was improved in the two- mice version. Interaction with shared input devices also led to greater equity between the different gender pairings, whereas interaction with only one input device led to poorer performance in mixed gender and male pairs. Analysis of the dialogues showed that the different gender pairings displayed very different styles of work. Only the female pairs used the type of discussion that characterises collaborative work. Our analyses of the processes of interaction are ongoing and we hope to shed further light on how the shared version of KidPad supports different forms of collaboration in storytelling.

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Appendices

Appendix 1: Text of the poem that was used

"Twinkle twinkle chocolate bar
Your dad drives a rusty car
Press the starter
Pull the choke
Off he goes in a cloud of smoke"

Appendix 2: The coding scheme

	Category	*Subcategory*	*Class*	*Example*
Giving statements	*"I" Statements about own work*	*Intention / Action*	*1a*	*"I'm going to put a car"* *"I've made it wobbly"*
		Opinion / Suggestion	*1b*	*"I think…"* *"I need…"* *"I could do…"*
	Joint "We" directed statements	*Intention / Action*	*2a*	*"We're going to…"*
		Opinion / Suggestion	*2b*	*"We need to see a starter in the car"* *"Let's move along"*
	Other directed "You" statements	*Instruction / Direction*	*3a*	*"Leave it like that"*
		Suggestion	*3b*	*"You could do the wheel"*
	Giving Information / Explanation		*4*	
Asking statements	*Asking for information / explanation / technical help*		*5a*	*"What's a choke"* *"How do I zoom"*
	Asking for suggestions / opinions		*5b*	*"Which one shall I get"*
	Agreements / give support		*6*	*"Yeah"*
	Disagreements / don't support		*7*	*"No you're not"*
	Off task		*8*	